Congestion Management

Acquiring strategic importance in power market operations

Satyajit Ganguly, Head, Operations, PXIL

In a competitive power market, the system is said to be congested when the volume of transactions exceeds the transfer capability of the transmission corridor. This implies that congestion impedes consumers from buying power from the cheapest source. Congestion management deals with conceptualisation, design and implementation of schemes to relieve transmission congestion.

Transfer capability

Transfer capability is the maximum ability of interconnected electric systems to transfer power from the source to the destination. It is directional and related to generation, demand and network topology. The capability is limited by the physical and electrical characteristics of the electrical system including any one or more of the following:

- Thermal limit
- Voltage limit
- Stability limit.

The thermal limit indicates the maximum electrical current that a transmission line can conduct before sustaining permanent damage due to overheating. This limit cannot be breached at any time. The voltage limit refers to the maximum power that can be transferred without reaching critical voltage in any mode. The stability limit indicates the maximum power that can be transferred without loss of stability. The limiting condition on a transmission corridor could shift between the three limits as the network operating conditions change over time.

Available transfer capability

Available transfer capability (ATC) is a measure of the transfer capability vacant on a physical transmission corridor for commercial activity over and above the committed contracts. It is derived from the total transfer capability (TTC) after discounting the reliability margins. The ATC is used as a limit for scheduling long-term as well as short-term transactions, with the former having priority over the latter. The ATC for all regions in India in August 2009 is listed in Table 1.

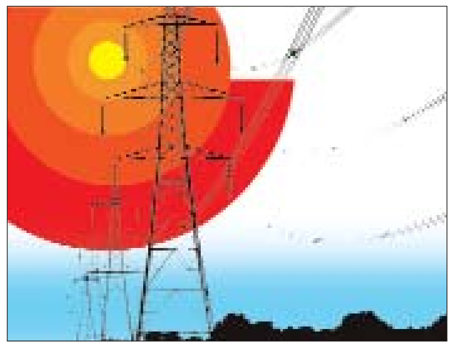
Reliability margins in the form of transmission reliability margin (TRM) and capacity benefit margin (CBM) can be used by all transmission users for a variety of potential system conditions.

Congestion management

The primary objective of congestion management is to solve congestion problems in an economically efficient manner, both in the short and long run. There are two congestion management methods: preventive management, which is used before the day of operation; and curative management, which is used in real time. Explicit auction, implicit auction and counter trades are methods for preventive management, whereas redispatching is a form of curative congestion management.

Preventive congestion management

Explicit auction: Under explicit auctions, the transmission system operator of the system in which congestion exists sells the interconnection capacity to the highest bidder. Design variations are possible with regard to the bidding mechanism, time period of auctions and firmness of capacity rights. This separates energy flow from transmission capacity.



Explicit auctions require a separate transaction for trading electricity, and the services of a power exchange are thus not required for obtaining transmission capacity.

Implicit auction: Bids from market participants are collected from various bid zones (a bid zone is an electrically contiguous area where congestion is possible within the zone only) so that the market operator (power exchanges in India) can aggregate the supply and demand curves for each bid zone.

In the first iteration, the supply and demand bids across all zones are aggregated to determine an unconstrained market clearing price (UMCP). In the next iteration, the demand and supply volumes in each bidding zone are aggregated, with the difference between them representing the amount of unconstrained flow from/to that zone.

If this flow exceeds the transfer capability across the zones there is congestion, following which the market spitting algorithm is initiated.

Market splitting involves separation of the congested zone from the rest of the system. The price within the congested zone is adjusted to drive the demand-supply gap to a level to match the transfer capability. This method is currently used by the power exchanges in India.

Counter trading: Under this method, the system operator initially undertakes a merit order unconstrained dispatch. Counter trading takes place at the least cost on the basis of bids and offers

Table 1: Available transfer capability in August 2009, by region (MW)

Region	Particulars	Importing region	Time period (from-to) (hours)	TTC	Reliability margin	Scheduling limit*	LTOA	ATC for STOA
Western region (WR)	Import capability		00-18					
			22-24	1,500	500	1,000	432	568
		ER	18-24	1,500	500	1,000	370	630
		NR	00-24	1,200	200	1,000	55	945
		SR	00-24	1,000	250	750	0	750
	Export capability		00-18					
			22-24					
		ER	18-22	1,000	200	800	0	800
		NR	00-24	1,500	200	1,300	0	1,300
		SR	00-24	1,000	200	800	0	800
Southern region (SR)	Import capability	ER	00-24	3,360	50	3,310	1,779	1,531
		WR	00-24	1,000	100	900	0	800
								Limited to WR ATC
	Export capability		00-17	2,900	1,300	1,600	188	414
		ER	27-24					Limited to ER ATC
			17-23	2,900	1,300	1,600	188	314
		WR	00-24	1,000	100	100		750
Eastern region (ER)	Export capability		00-24	2,800	300	2,500	1,226	1,274
			00-24	1,700	500	1,200	411	789
		NR	23-24					
		WR	17-23	1,700	500	1,200	382	818
		SR	00-24	1,695	50	1,645	87	1,558
		NER	00-24	500	100	400	107/113	293/287
	Import capability	NR	00-24	400	100	300	0	300
		WR	00-24	500	100	400	0	400
		SR	00-24	750/650	50	700/600	186	514/414
		NER	00-24	300	100	200	0	200
Northern region (NR)	Simultaneous import capability	Simultaneous import by NR	00-24	3,750	500	3,250	1,126	2,124
		Import from ER	00-24	2,800	300	2,500	1,126	1,374
		Import from WR	00-24	1,500	200	1,300	0	1,300
		Exporting region	**Time period (from-to) (hours)**	**TTC**	**Limiting conditions**			
	Simultaneous export capability (1,500 MW)	Simultaneous export by NR	00-24	1,500	Voltage constraints in NR system, overloading of 400 kV Agra-Gwalior and 220 kV Morak-Badod links			

*TTC: Total transfer capability; LTOA: Long-term open access; STOA: Short-term open access; NER: North-eastern region; * LTOA+STOA=TTC-reliability margin*

received from the participants. If the transmission flows are not possible, the system operator trades power against the flow to ensure feasible dispatch.

Curative congestion management

Redispatching: In redispatching, the system operator increases the generation or cuts load in the congested zone, and decreases generation or withdraws load shedding in the surplus zone, to ensure that the actual flow is lower than the transfer capability.

Current scenario

Bids from market participants are currently referred to the various bid zones, so that the power exchanges can aggregate the supply and demand curves for each zone. In the initial iteration, the supply and demand across all zones is aggregated to calculate the UMCP. The algorithm calculates the cleared unconstrained schedules for all market participants based on the UMCP. Thereafter, both the exchanges submit the unconstrained solution to the National Load

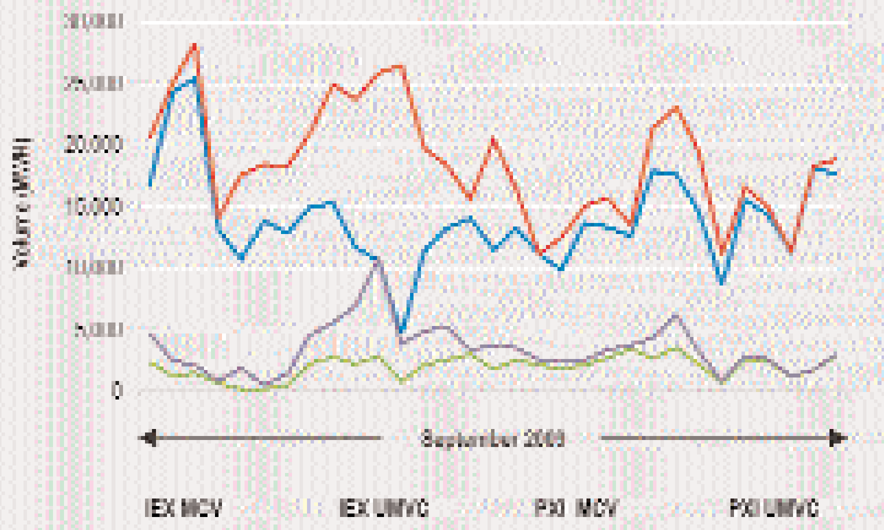
Despatch Centre (NLDC). The NLDC notifies the maximum trading capacity across all bid areas on a 24-hour basis pro rata between the exchanges. This trading capacity is limited to the ATC discounted by the sum of the approved long-term open access (LTOA) and short-term open access (STOA).

In the next iteration, the supply-demand balance within each zone is aggregated, with the zonal imbalance representing the amount of transmission from/to that zone. If this calculated transmission amount exceeds the permitted transmission capacity, there is transmission congestion and the market splitting algorithm is initiated.

The price for a surplus area will be less than the UMCP, whereas the price for a deficit area will be more than the UMCP. This leads to a surplus fund, known as the congestion revenue fund, equal to the product of the area price difference and used capacity.

There was congestion almost every day between the northern grid and the rest of India between April and September 2009. Congestion was also observed between the southern grid and the north-east-west grid in December 2008 and January 2009. As a result, congestion management had to be done through market splitting almost on a daily basis.

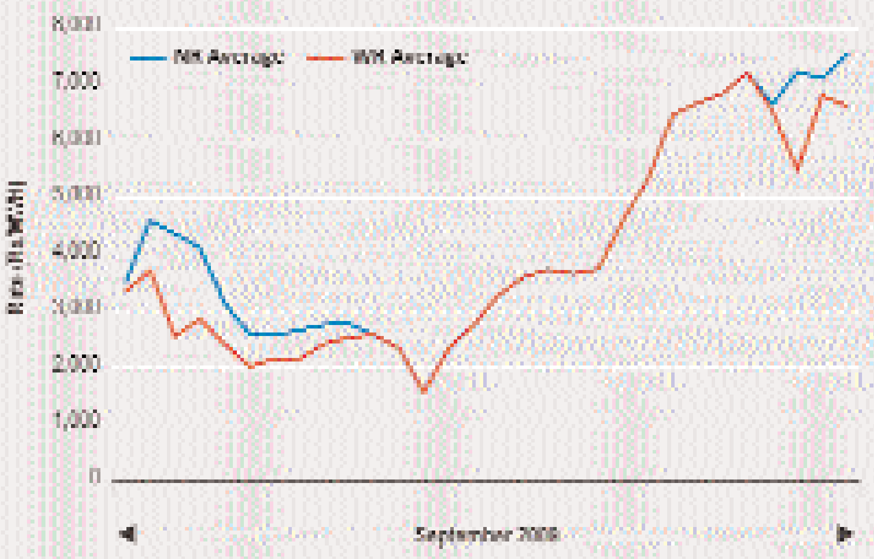
Fig. 1: Effect of congestion on exchange volume



Problems in congestion management through market splitting

In an unconstrained market, even in the event of a buyer bidding at a very high price (substantially higher than the other bids), the buyer may get cleared at an MCP much below his outlying high bid due to the presence of other buyers with lower bids in the unified national control area. This is because the MCP is determined by the intersection of the demand and supply curves, based on the aggregate demand and supply bids submitted by the respective entities.

Fig. 2: Effect of congestion on MCP average (IEX)



The current power market suffers from low liquidity, with sometimes just one buyer or seller being present in a bid area. In such a case, if one or a few price-insensitive and desperate buyers are present in a congested region, a large chunk of power (more than the transfer capability) would flow from the uncongested area to the congested area through the unconstrained solution, resulting in market splitting.

The MCP after market splitting for the congested region will be very close to the bid price due to the lack of bidding entities. As a result, a buyer is more likely to pay closer to his bid value (which has been as high as Rs 18 per unit, depending upon the need for guaranteed supply) in the congested area. This explains the prevalence of high prices in the northern region in May and September 2009.

The other impact of congestion is reduction in trade volumes on exchanges as the market clearing volume (MCV) after congestion comes down sharply from the unconstrained market clearing volume (UMCV). Fig. 1 shows the effect of

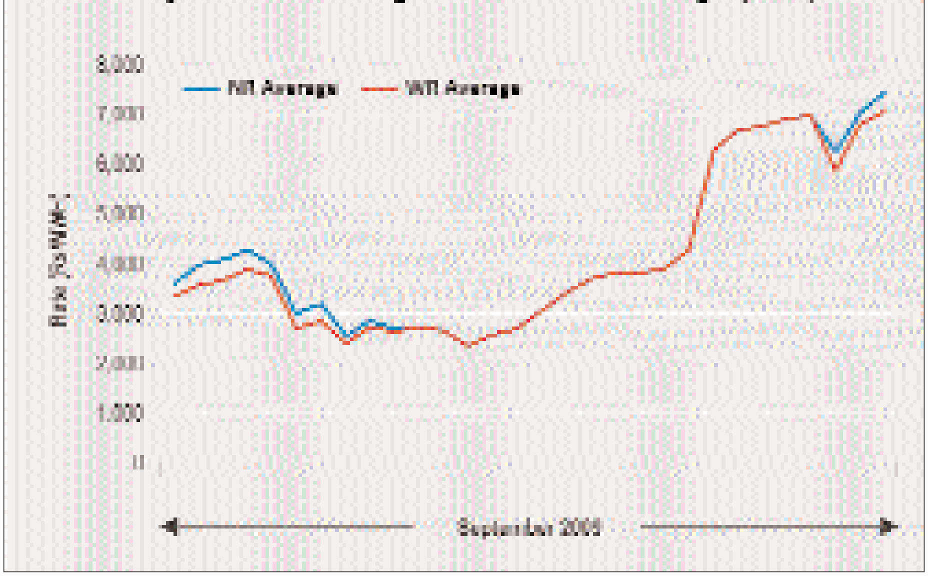


Fig. 3: Effect of congestion on MCP average (PXIL)

congestion on MCV for both the exchanges in August 2009. Market splitting also leads to a higher price in the congested area, as was seen in the northern region in August 2009. Figs 2 and 3 illustrate the effect of congestion on MCP for both the exchanges.

In addition, the current method of congestion management through market splitting results in discontent amongst both buyers and sellers. Buyers in congested areas resent the high prices being charged, whereas the sellers in surplus areas resent the low prices being paid. The buyers and sellers are also unhappy as the cleared volume after congestion is much lower than the unconstrained volume, which upsets the load generation balance and disturbs the scheduled load-shedding plans.

Congestion revenue

In more matured markets, congestion revenue generated on an exchange is utilised by the system operator for augmenting capacity on transmission lines which are subject to frequent congestion. In India, however, such a system would pose unique problems as the power exchanges currently account for only about 0.5 per cent of all power market transactions. Therefore, it would be difficult for the fledgling market to bear the burden of transmission capacity augmentation. Moreover, unlike the Nordpool market where the market splitting mechanisms were developed, the power exchanges in India do not have control over all the interregional interconnectors. Also, unlike Nordpool, where congestion is not a very frequent occurrence, there is almost constant congestion in the Indian power market. This is leading to a perception that power exchanges result in high prices, whereas the fact is that the high price includes the implicit cost of the transmission corridor.

According to para 5.3.2 of the National Electricity Policy, 2005, "Network expansion should be planned and implemented keeping in view the anticipated transmission needs that would be incident on the system in the open access regime. Prior agreement with the beneficiaries would not be a precondition for network expansion. The CTU/STU should undertake network expansion after identifying the requirements in consultation with the stakeholders and taking up the execution after due regulatory approvals."

It is thus evident that the congestion fund was never meant to be used for relieving congestion. Ideally, investments should be guided by the need to relieve congestion, and the transmission pricing mechanism should have a component based on network congestion which specifically signals the need for capacity expansion.

Buyers and sellers usually blame power exchanges for higher prices being charged and lower prices being paid. Some sellers have even gone to the extent of asking Power Exchange India Limited to refund the difference in amount. As the power exchanges have been operating for only about one year, such resentment on the part of the market players may hamper the development of the exchanges.

Congestion management needs to be undertaken in a manner suitable to the uniqueness of the Indian market. The deficit region should be treated as a radial load to the surplus region, with the interconnector capacity maintained at the level of the ATC. This would lead to a UMCP for the entire national market with no difference in prices. Naturally, there would not be any congestion fund. All the players in the market, irrespective of geographical location, would pay the same price for buying or selling power.

Conclusion

The National Electricity Policy, 2005 envisions 85 per cent of power from new capacities to be contracted through long-term contracts, with the remaining 15 per cent available for the power market. Much more merchant capacity is expected to be available in three to four years. Power exchanges are also expected to increase their liquidity in a couple of years, which will be used extensively for the short-term balancing needs.

Due to the above reasons, the flow quantity and direction would be very difficult to forecast and could result in additional transmission congestion across all possible flow gates. Congestion will therefore be an integral part of the Indian power grid. As a result, congestion management will become very important for ensuring safe and secure grid operations, and acquire tactical importance in market operation. ■